The quadrate is a stout bone, having three well-defined processes, one forming the articular surface for the mandible; a second, answering to the otic process of the primitive suspensorium, articulates with the squamosal; and the third, or orbital process, projecting forwards and upwards, is the pedicle or true apex of the mandibular arch. The otic process, besides articulating with the squamosal, bears a small facet for the prootic; this, in many birds, is developed into a distinct secondary head.

Immediately behind the quadrate is seen the large tympanic cavity; this is banded above by the supra-occipital and squamoid, below by the basi-temporal, behind by the ex-occipital, and in front by the basi-sphenoid; it sends into the latter a diverticulum, the anterior tympanic recess, and a second or posterior recess into the supra-occipital, through the diplöe of which it is continuous, as in the crocodile, with the tympanum of the opposite side. The fowl resembles the ostrich, and differs from most other birds in being wholly devoid of a tympanic bone.

The lower jaw consists of the same elements as already described in the snake, except that the coronary is absent in the fowl, though present in most birds; in this stage the five bones (articular, angular, supra-angular, dentary, and splenial) are perfectly distinct, and Meckel's cartilage yet remains of considerable size.

The upper part of the hyoid arch is separated, as in the snake and frog, to form with the stapes a *columella auris*. From the oval, irregular, plug-like stapes proceeds a slender rod of bone terminated by a triradiate cartilage, of which the slender antero-inferior bar is the infra-stapedial, the broad somewhat expanded central segment the extra-stapedial, and the postero-superior bar the supra-stapedial. The latter is connected by an oblique bar with the extra-stapedial. The stylo-hyal is represented by the free end of the infra-stapedial.

The tongue-bone consists of a body made up of glosso-hyal (formed by the union of the lesser cornua), basi-hyal, and basi-branchial (uro-hyal) arranged in a linear series; and of two pairs of cornua, the anterior or cerato-hyals, very small, and forming more lateral projections to the body, and the posterior or epi- and cerato-branchials (thyro-hyals), long and elastic, and embracing the occipital.

The development of the fowl's skull has been worked out as far back as the fourth day; but even at that early period, when chondrification is only just beginning to set in, it is impossible to demonstrate with certainty the distinctness of many regions which are perfectly separate at corresponding stages in the lower types. At the period mentioned, the indifferent tissue of which the trabeculæ are formed is perfectly continuous with that of the investing mass, and this again with that of the auditory capsules. When, however, the process of conversion into cartilage is complete, the apices of the trabeculæ become perfectly distinct from the investing mass, and form a pair of backward-turned horns (often called the *linguæ sphenoidales*) on either side of the pituitary space. The ear capsules, on the contrary, remain as undistinguishable from the para-chordal region after chondrification as before, and only acquire distinctness by ossification. This rapid process of fusion which takes place equally between the masses of indifferent tissue constituting the primordial skull, in the subsequently formed tracts of cartilage, and in the various ossifications of a still later period, renders the study of the bird's skull one of the most difficult problems of craniology.

The manner in which the hyoid arch is developed has been worked out more exactly in the house-martin than in the chick, in which, however, the process is essentially similar. At a very early period the upper end of the arch grafts itself on to the auditory capsule, and at the same time becomes split up into three portions. The proximal of these constitutes the columella, a plug of the auditory capsule being before long cut out around its attached end to form the stapes. The middle is the stylo-hyal; it is at first connected to the columella by a tract of tissue, but afterwards fuses with the infra-stapedial element of the latter. The distal portion never becomes chondrified in its upper portion, resembling in this respect the corresponding structure in man (the stylo-hyoid ligament), but below forms the lesser cornu of the hyoid bone, or cerato-hyal.

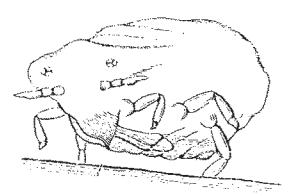
The mode of formation of the complex basi-sphenoidal region is, perhaps, the most important point which yet remains for consideration. No endogenous ossification takes place in the cartilage of this part of the basis cranii, but a pair of symmetrical ossific centres make their appearance in the thick web of perichondrium which underlies it, a third (median) centre appearing at the same time in front of the other two in the fibrous tissue below the ethmoidal cartilage. These ossifications together represent the dagger-shaped parasphenoid of the frog; the anterior is commonly known as the basi-sphenoidal rostrum; the posterior pair, coalescing, form the basi-temporal. Before they unite, however, ossification extends from them into the overlying cartilage, and thus the true basi-sphenoid is formed in a manner perfectly unique among vertebrata.

THE NEW VINE-DISEASE IN THE SOUTH-EAST OF FRANCE *

II.

HAVING thus far studied the spread of the new vine-disease and the extent of the ravages committed by the Phylloxera, it is time to turn our attention to the insect itself, and to state the results of scientific observation of the manner in which it attacks the vine rootlets, and the various circumstances and conditions which either favour or retard the development of the disease.

The Phylloxera is a very minute insect, measuring, when fully grown, not more than 1-33rd of an inch in length. Its most striking feature is its proboscis, which lies in a sort of groove on the under-side of the insect, and with which it pierces the roots on which it feeds. This proboscis is very slender, and appears to be formed of three tongues, a greater one in the middle, and two more slender and shorter, on the two sides of it; it resembles a brown thread bending round and inserting itself in the tissue. The base of the proboscis is a sort of



The Phylloxera.

flat and sharp-pointed blade, composed of brown parts which prolong themselves into the tongues. The animal raises this blade a little in applying its proboscis to its food. The length of the sucker is equal to about half that of the body of the Phylloxera, which does not bury more than half of it in the bark of the roots. By this sucker the insect fixes itself to the spot which it has chosen, so that it can be made to turn upon it as on a pivot. In colour the Phylloxera, during the summer at least, is yellow, but in the late autumn it turns to a copper-brown tint, which lasts through the winter. The active life of the Phylloxera lasts from the beginning of April till the latter half of October. The insect hibernates through the other months, though previous to the commencement of hibernation the females who have laid eggs during the

* Continued from vol. x. p. 506

past season, die off, leaving only young insects, which, as we have said, turn to a copper-brown colour at this period, renewing their light yellow tint in the spring. The Phylloxeras do not increase much in numbers during the months of April and May, but an extensive reproduction of the insect is clearly marked in June and July, while it assumes prodigious proportions in August and September, in the latter months often covering the root-shoots in a continuous mass, so as to make them appear completely yellow with their bodies. In observing the spots attacked by the Phylloxera, two varieties of the insect—a winged and a wingless—have been generally found; but it would seem (though on this point the reports before us are not quite clear) that the one is but a later development of the other. The wings of the Phylloxera do not appear to be capable of sustained flight, but probably help to carry the insect along from place to place when exposed to the action of the wind, for several specimens of the winged variety have been discovered caught in spiders' webs. Of course the winged Phylloxera spreads over the vineyards, which it attacks without any regard to the nature of the soil, whereas the wingless variety is much affected in its movements, and the extension of its ravages is largely determined by the quality of the ground and the nature of the obstacles to which it is exposed. Passing by, for the present, the observations made on this point, we may say generally that the insect would seem to have no burrowing power, but moves from place to place, from root to root, along the line of the fissures which the soil presents.

M. Maxime Cornu, as a result of his observations, has come to a conclusion contrary to the most commonly accepted theory of the cause of the disease of the vine, which attributes it to the absorption of the sap by the insect, and holds that the Phylloxera does not divert the sap to its own body, basing his conviction on his observations as to the length of the portion of the sucker buried in the rootlet compared with the thickness of the bark. He considers that what the Phylloxera really feeds on is the contents of the cellules of the bark, and perhaps of the cambium layer. An exaggerated power of absorption has, in his view, been attributed to the Phylloxera, and it would rather seem that the flagging and ultimate decay of the vine arises, not from the absorption of the nutritive elements by the insect, but from the formation of new tissues, which divert them from their proper end to nourish abnormal growths. These new tissues or swellings (*renflements*) of the roots are probably caused by an irritation of the cambium layer, the result of which is the hypertrophy of the excited part, while the formation of the swellings brings about the death of the rootlets, and through them the general decay of the vine. A natural conclusion from these observations is that the health of the vine may be improved by any means tending either to produce fresh rootlets or to increase the absorption of nutritive elements by those already in existence, though the only true and radical remedy is to kill or drive away the Phylloxera itself.

When a vine is first attacked by the Phylloxera, a change occurs in the external appearance of the rootlets, which, instead of being nearly cylindrical, exhibit the swellings we have just mentioned of different shapes, which are the first symptoms of the disease. The Phylloxeras may often be seen on their surface. These swellings are hard, and of a greenish or yellowish, or sometimes of a deeper-coloured tint, according to that of the external coat of the root when they are full of sap, but when they rot they become black and flabby, and eventually dry up altogether.

It is interesting to examine and compare in the same root the structure of the part above the swellings with that of the swelling itself, as by these means one can come to a definite opinion, by comparing the diseased with the healthy part, as to what are the new elements which are developed, and what are the characteristics of the altered parts. By making a transverse section above a swelling in the vine, the structure is found to be that of a normal root-shoot; and, with the aid of a microscope magnifying 60 diameters, the following appearances may be observed:—(1) On the outside the external coat (*couche subéreuse*) composed of flattened cells, arranged in rows and brown on the outer side: this tissue peals off in layers of a brown colour, and it is this that gives the rootlets the yellow or brown tint they show according to its thickness. (2) The cortical parenchyma, composed of polygonal cells, full of starch, some of which, larger than the rest, scattered about here and there, contain bundles of raphides, long crystals parallel to each other. These two constitute the cortical coat. (3) The woody portion, composed of fibres and vessels, occupies the centre, and is divided into three, four, or five woody sectors, and between each two of these is a medullary ray—there is no definite pith. (4) Embracing the woody tissue and in contact with the cortical coat is the cambium layer, the flattened cells of which, with their thin walls, full of a thick plasma and always destitute of starch, form on the one side the cortical and on the other the woody tissue. The general contour of the section is circular. To turn to the swellings.—The increase in diameter is due to the formation of new elements, partly cortical, partly woody, the cortical parenchyma becoming much thicker, but otherwise resembling the healthy tissue. It is different with the woody tissue: the woody rays assume very irregular outlines, and swell in all directions unevenly beyond the limit of the single concentric circle which terminates them with its circumference, in the healthy state. The development of the cambium layer is also abnormally increased, and there seem to be no vessels in the new wood formed under these conditions.

This altogether anomalous anatomical constitution is in itself a refutation of those who even now hold that the swellings are the result of normal growth. They really are a purely local hypertrophy produced by the direct action of the parasite.

It is of great importance to the discussion of possible means of extirpating the new insect, to investigate the method it employs in getting from place to place and so spreading its ravages. Putting aside as obvious the movements of the winged variety, which, as we have said, seems to be borne to fresh spheres of mischief by the wind without any direct effort of flight on its own part, we come to the wingless insect. Observation shows that the wingless Phylloxera progresses both along the surface of the earth and follows also the line of the roots or the fissures of a crumbly or broken soil. And first, to deal with the surface-movements of the insect, they appear to be extraordinary occurrences, the results of the concourse of altogether special circumstances, for the exposure to the air and to the sun's rays is very unfavourable to the Phylloxera, which in the dry air dies of desiccation, as may be easily shown by leaving exposed a root covered with Phylloxera. It would seem, therefore, and observation supports this idea, that the reason of the surface-movements of the insect lies in the fact that in getting from vine to vine, or sometimes from rootlet to rootlet, it encounters obstacles which, not being a burrowing insect, it cannot overcome, and therefore from unwelcome necessity it has to mount to the surface, though only to bury itself again when the next fissure shows itself, leading to a fresh and unattacked part. With respect to the movements of the parasite underground, some elaborate observations have been made by M. Duclaux, and it is worth while to examine his results. If one were to ask himself, *à priori*, which kind of soil among those that prevail in the south-east of France offers the greatest difficulty to the movements of the Phylloxera, the answer which would inevitably suggest itself would be that the sandy varieties are the least per-

meable by it. A clayey soil offers, as observation proves no less than reason, great facilities to the passage of the insect, which is not hindered by its slippery nature when wet, for it can walk without difficulty up the vertical sides of a glass bottle. Such a soil cracks everywhere in drying, and forms fissures in all directions, vertical and horizontal, thus laying bare the roots of the vines in many places; moreover, the digging and dressing of the vine leaves the soil in lumps about the roots, separated by numerous chinks which afford every facility to the passage of the insect. A calcareous soil generally resembles a clayey one with respect to the means it affords for the movements of the Phylloxera; it is only when the limestone it contains is disseminated through it in the shape of sand or small gravel that a calcareous soil at all resembles in its properties a sandy formation. This latter kind it is, which, being always dry, always well settled, constantly enveloping the roots on all sides, puts great obstacles in the way of the circulation of the insect, which can find no chinks large enough for its purposes underground, while on the surface it gets entangled in its movements like a fly in a dish of honey. A soil formed of large pebbles cemented together with clay will not, however, be favourable to the Phylloxera, for it does not crack like the purely argillaceous formation; and though the vine, which can push its way everywhere, does so there also, the insect cannot. A very little clay more or less serves to give very different properties to the earth from the point of view of the Phylloxera, and hence it is that one can explain a phenomenon often noticed, namely, a small portion of a vineyard remaining in a flourishing condition in the midst of general decay. A close examination of the soil in these cases removes all cause for wonder, for a lump of damp earth taken from the diseased quarter and pressed between the fingers may be worked and moulded like dough, while a piece taken from the healthy part crumbles and is less tenacious. Were it otherwise at all doubtful, figures would show that the vines in the south-east of France are healthier or the reverse, according as the soil is less or more clayey. Thus a physical analysis of some earth taken from a vineyard of M. Faucon, at Graveson, where all but one little plot was subjected to the attacks of the Phylloxera, gives the following results:—

	Healthy part.		Diseased part.
Water	2·25	...	3·20
Nitrogen	0·11	...	0·12
Sulphate of calcium	0·62	...	0·42
Chloride of sodium	1·15	...	0·18
Carbonate of calcium	49·00	...	42·00
Siliceous sand...	23·50	...	10·20
Clay	17·75	...	37·50
Organic substances and errors of analysis	5·62	...	6·38
	100·00		100·00

Among the different varieties of soil which are more or less favourable to it, the Phylloxera as one would suppose without observation shows traces of its presence in a poor dry and shallow soil first of all, then in clayey damp ground, and after that in calcareous tracts, according to the degree of difficulty which vines, planted in these soils, present to its operations; eventually, in the same way, the disease shows itself in other kinds of earth, with a rapidity or the reverse which is in proportion to the amount of strengthening juices which the vine can imbibe from them, and the obstacles which the insect meets with, till at last no vines are left intact but those which are planted on a soil impenetrable to the parasite. This phenomenon, if such it may be called, of the disease, will serve to explain, what we have already discussed in a former article (vol. x. p. 503), the spread of the disease in its earlier years, and the great and alarming increase of the extent of territory affected in 1867-1868. Regarding the observations just made, we can see that probably the Phylloxera was spread over the whole area of the two departments of Vaucluse and Bouches-du-Rhône, which in the two last-mentioned years were so formidably damaged in their vineyards, as early as 1865, when the disease only *appeared* on the plateau of Pujaut. The alternative hypothesis, that the disease radiated from a central point at Pujaut, presents great difficulties, as it does not allow sufficient time for the emigration of the insect to the points where it appeared in 1867-1868, while it makes it leave a district not in any way exhausted, disregarding the known habits of the Phylloxera. It would seem, therefore, that we may put aside any idea of a progressive irradiation of the disease around a single centre, and explain existing facts by attributing them to a general dissemination of Phylloxera, before 1866, over the territory lying along the valley of the Rhône, between the Drôme and the sea, though the insect only showed traces of its presence according to the nature of the soil in different parts, in some sooner, in others later. We may, indeed, regard it as almost certain that the disease began with the invasion before 1865 of a vast surface, in which different points have shown the traces of the insect's presence successively, and that from a cause analogous to that which shows us, when an island emerges from the sea, its highest peaks appearing first, the others afterwards, in the order of their altitude. By the use of this illustration, supplied by M. Duclaux, we can set before ourselves a graphic picture of the history of 1865, 1866, 1867, and 1868 in the vineyards of South-eastern France.

We will not dwell at any length on the different attempts at treatment of the disease, as they have more practical interest for those who live in vine-growing countries. Many of these attempts have been failures, owing to their having been based on false hypotheses as to the origin of the disease of the vine. When, in July 1868, M. Planchon discovered the Phylloxera, attention was naturally turned to the employment of insecticides, but the difficulty lies, not in the discovery of a substance fatal to the insects and harmless to the vine, but in its application underground to all the parts attacked. It was soon found that those insecticides, at least, which are insoluble in water, cannot be applied generally to the seat of the disease, and this fact led to the trial of immersion, in the hope that, instead of being like many remedies suggested, only partial, serving merely to delay the death of the vine, it would prove a radical means of cure. M. Faucon was the first practical vine-grower to employ immersion, as distinguished from the mere watering of the vine; but this method, though entirely successful in his case in the parts where it was applied, is obviously not capable of universal adoption. The physical conformation of the soil, the absence of a water-supply from any river, and the fact that the finest vines grow on slopes, which are not of course amenable to this treatment, to which we may add its great expense, except in very conveniently situated districts, make it only practicable over limited areas. The remedy, therefore, which is to eradicate the Phylloxera and restore to France her full supply of wine, the national drink and the great source of national material prosperity, is still undiscovered. Science throughout France is striving its utmost to discover the potent method of destruction of the Phylloxera, little doubting that some such there is. The thought of thinking minds engaged on this subject should be like that to which M. Faucon so eloquently gives utterance:—"When we feel that we are threatened, and see that we are already attacked, have we no other resource than feverish attempts, barren lamentations, or a resigned submission? Yet help never comes but to those who deserve it, and who, in wrestling with the plague by which they are attacked, are obeying, whatever bigoted minds may think of it, the strict call of duty—nay, we may say a command of heaven itself."